Identification of clear AIRS fields

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BACKGROUND

- NESDIS will be distributing AIRS radiances to NWP centers in near real-time.
- NWP centers will assimilate clear radiances
- Need very good cloud detection algorithm

Objectives

- Provide information indicating if fov is clear with a confidence indicator.

- If not clear:
  - provide cloud amount and height.
  - indicate channels not affected by clouds

TOPICS

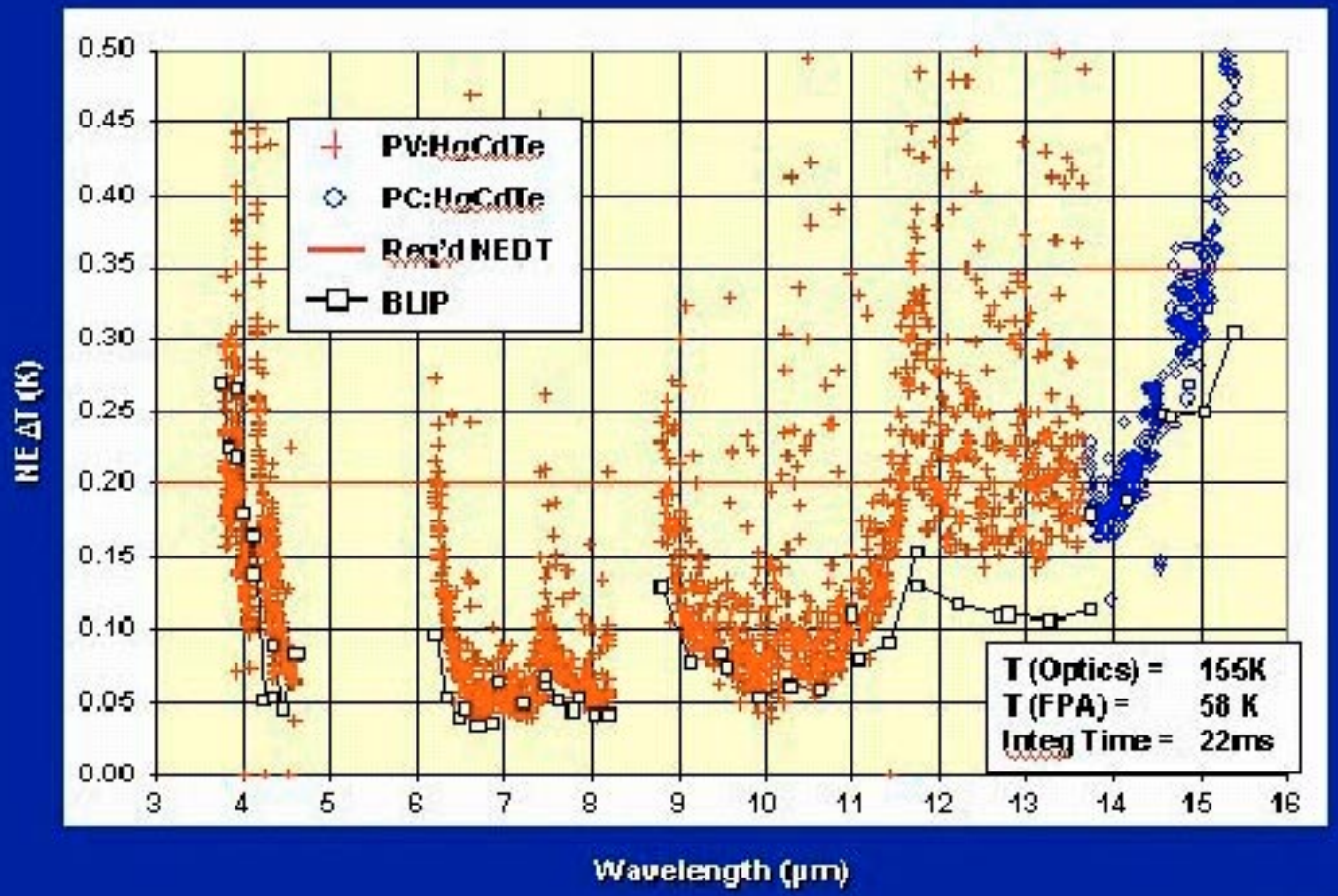
- AIRS instrument
- AIRS simulations
- Cloud detection
- Cloud height and amount
- Cloud Clearing

AIRS Instrument

- AIRS is a cooled grating array spectrometer
- Spectral coverage 3.7 to 15.4 microns in 17 arrays with 2378 spectral channels
- Spectral resolution $\nu/\Delta\nu$=1200, 15 km FOV from 705km orbit
- Primary products: temperature profile (< 1 K accuracy), moisture profile (< 15%)
- Accuracy is achieved in clear, cloud cleared, or above clouds

Measured Sensitivity (NEΔT)

Single Look (1.1° x 0.6° IFOV) - 250K Scene

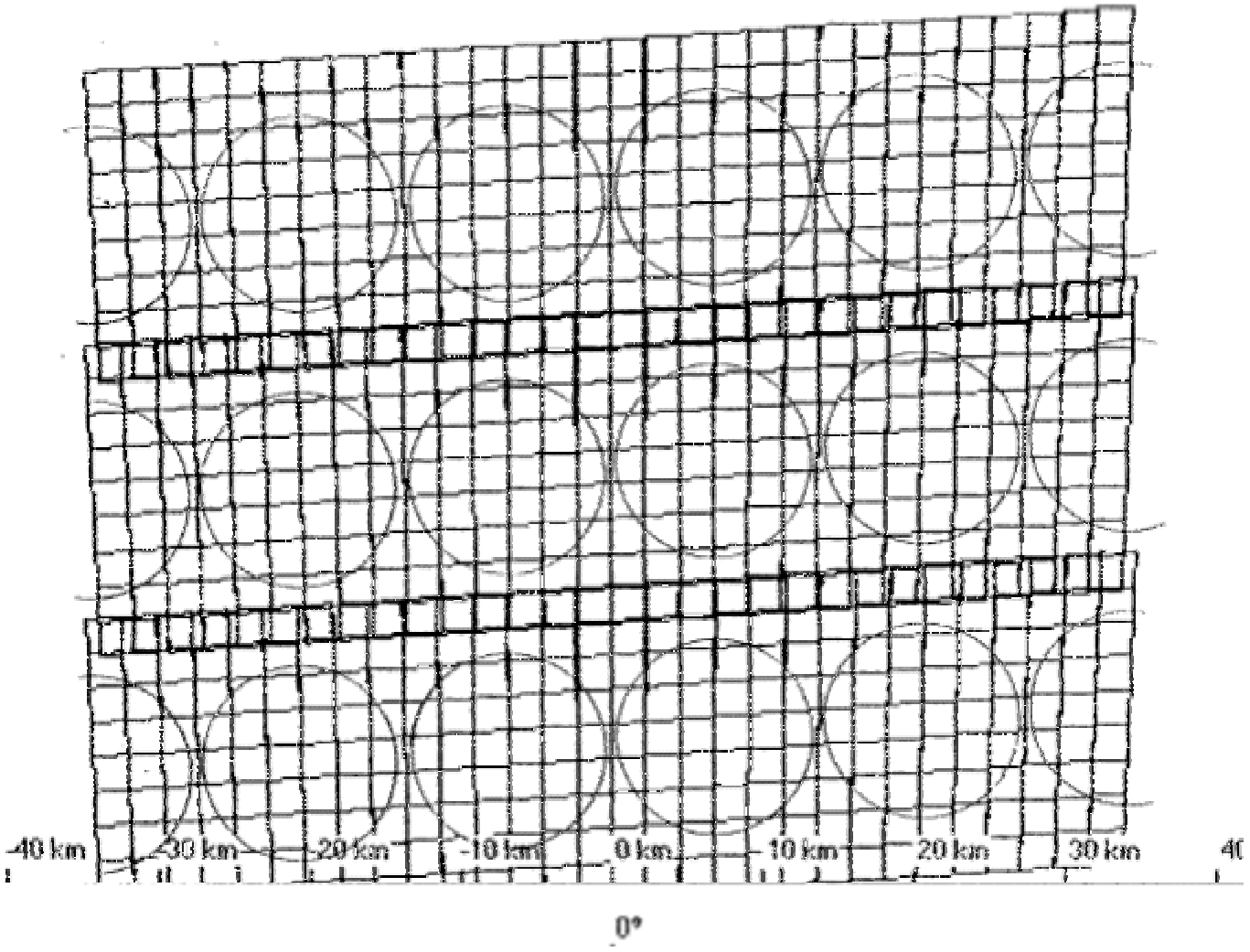


AIRS Instrument

- AIRS also includes 4 visible/near-infrared channels
- Channel 1 (0.40 – 0.44 um) - aerosols
- Channel 2 (0.58 – 0.68 um) - (AVHRR ch. 1)
- Channel 3 (0.71 – 0.93 um) - (AVHRR ch. 2)
- Channel 4 (0.48- 0.95 um) - broadband

VIS/NIR Schematic of Ground Location

Note: 1/3 over sampling - actually 8 pixels per AIRS fov in cross track; pixel size ~ 2.28 km.



AIRS Visible and Near-IR channels

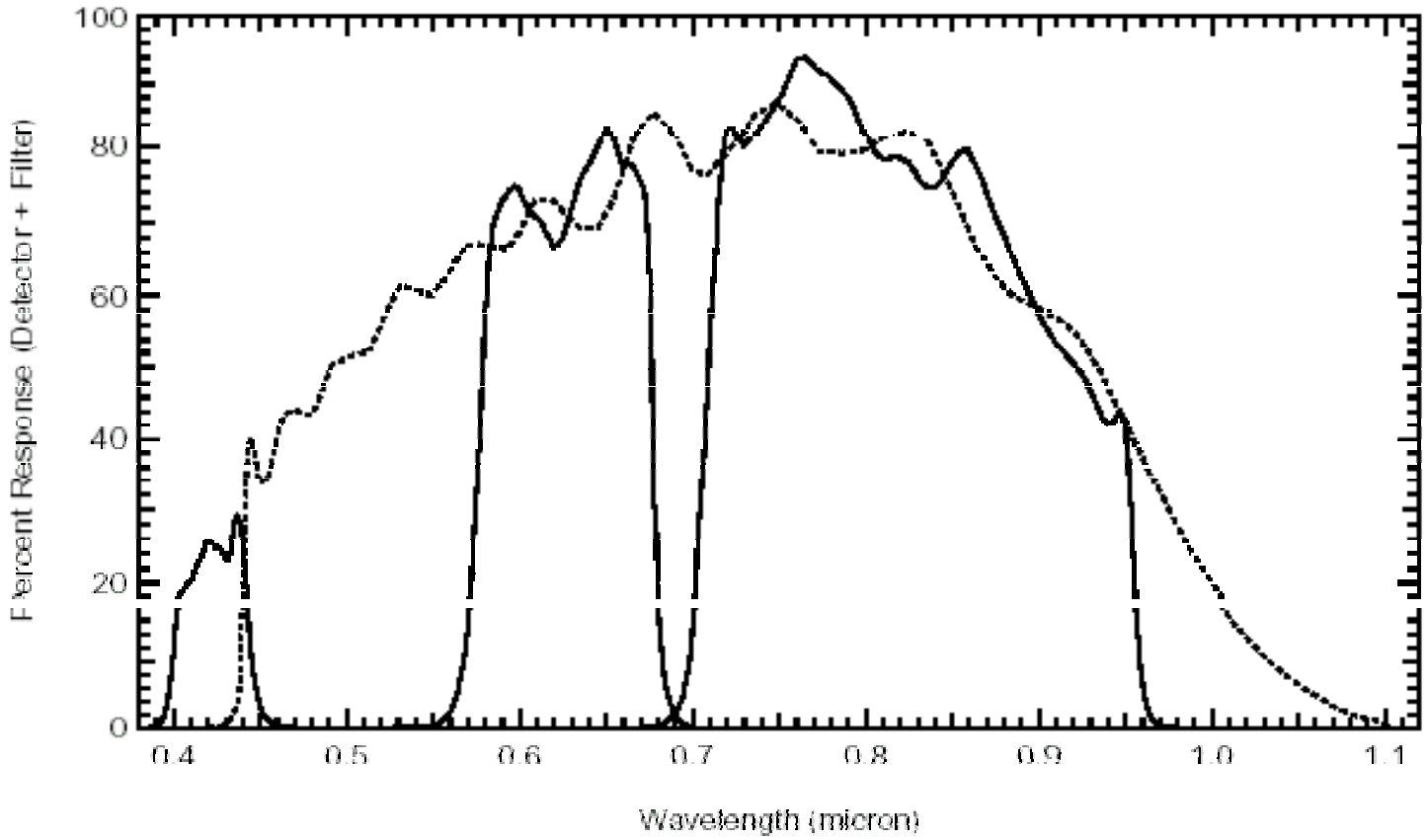


Figure 1.1: Approximate spectral response of the four Vis/NIR channels. The three solid curves are, from left to right, Channels 1, 2, and 3. The dashed curve is the response of Channel 4. Radiation damage over the five-year instrument lifetime will slowly degrade the longwave response of Channels 2, 3, and 4 (see Fig. 1.2).

AMSU and HSB Microwave Sounders

- AMSU and HSB are co-aligned with AIRS.
- AMSU has 42 km fov and is primarily a temperature sounder (15 channels)
- HSB has 15 km fov, moisture sounder (4 channels)
- AMSU and HSB are not affected by clouds (except for moderate-heavy precipitation)
- Provides “all weather capability”
- Provides clear estimate for cloud clearing
- Used in IR cloud detection tests.

AIRS Simulated Orbital Datasets

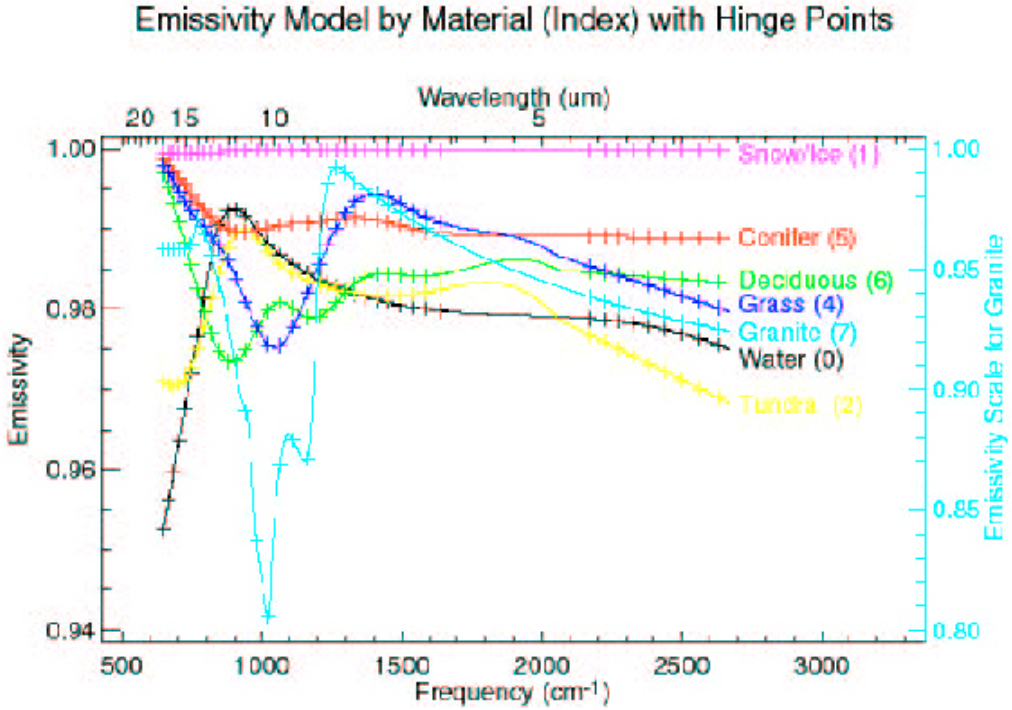
- Derived from the operational NCEP global model.
- Includes temperature, ozone, liquid water at 29 levels (1015 mb to 3 mb)
- Water vapor at 12 levels from 1015 to 300 mb.
- Water is extrapolated above 300 mb by q(300)*(p/300)**3.
- UARS climatology is append to the temperature above 3 mb.
- Data is interpolated to AIRS 3 x 3 locations within AMSU fov.

AIRS Orbital Datasets

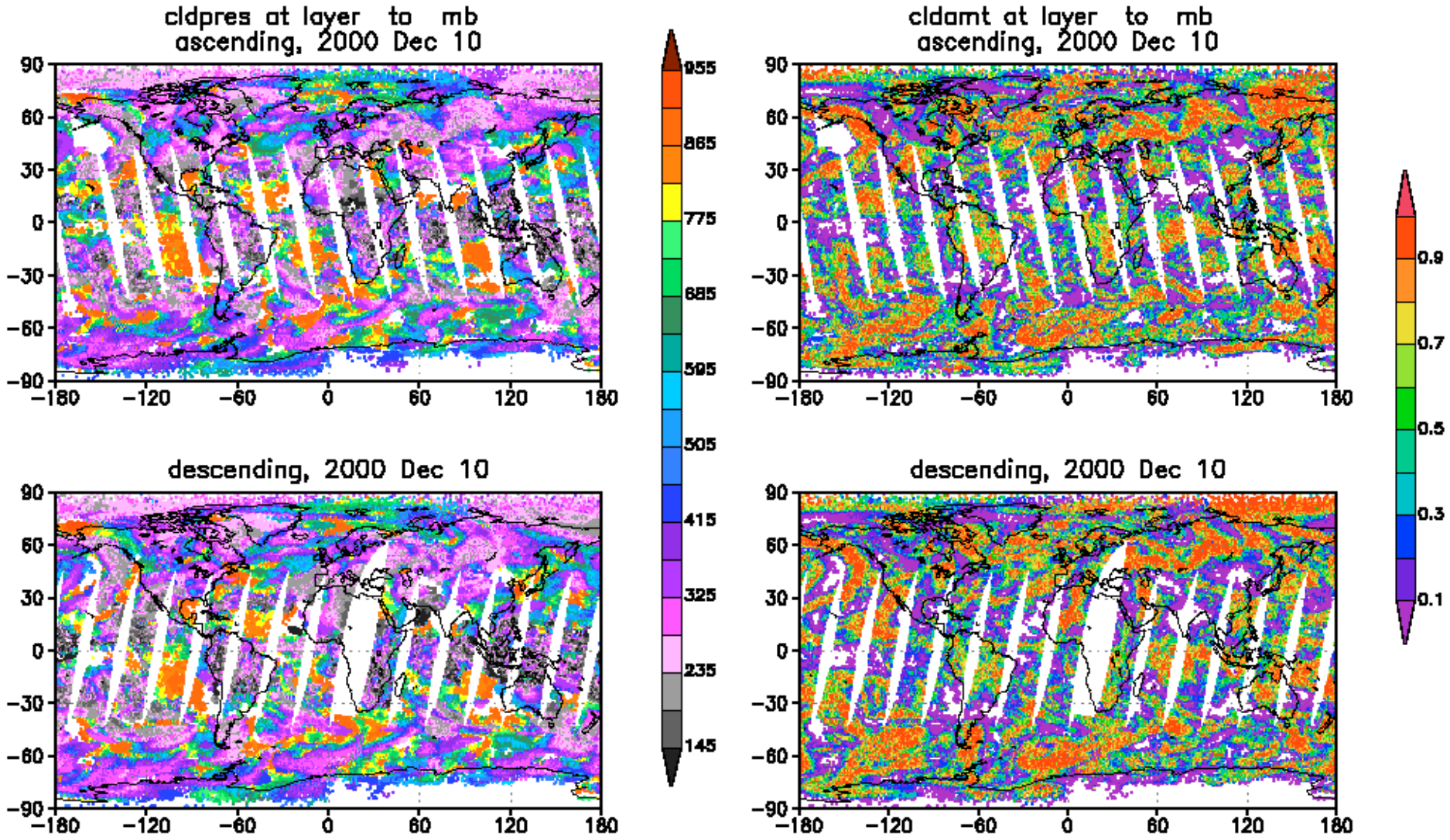
- Includes surface topography and variable surface pressure
- Daytime and nighttime conditions
- T(p),q(p),o3(p) from surface to .005 mb.
- cloud liquid water profiles
- multiple level cloudy conditions with spectrally varying cloud emissivity and reflectivity, consistent with atmospheric conditions (clouds from global model,but cloud amounts are randomized)
- variable surface skin temperature, surface emissivity and surface reflectivity
- variable land coverage with coastlines, lakes, etc.
- variable view and solar zenith angles

IR Emissivity Model

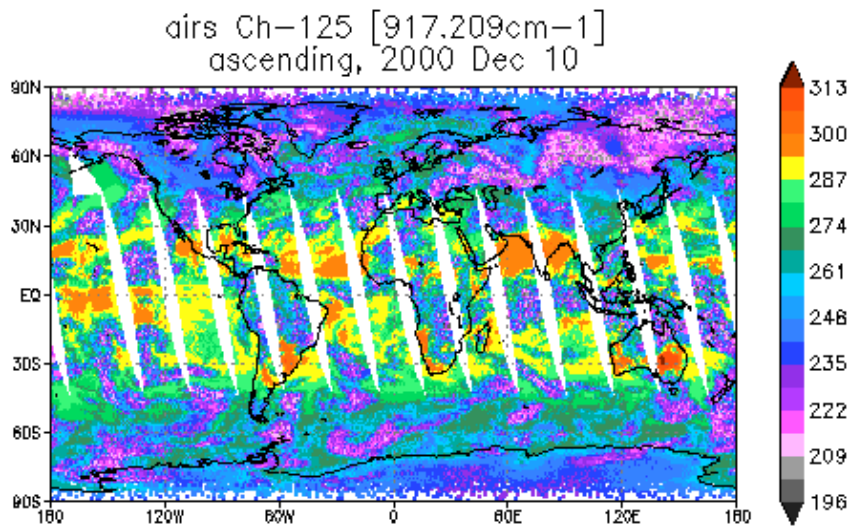
- Granite spectrum: IR handbook
- Others: spline interpolation of CERES database

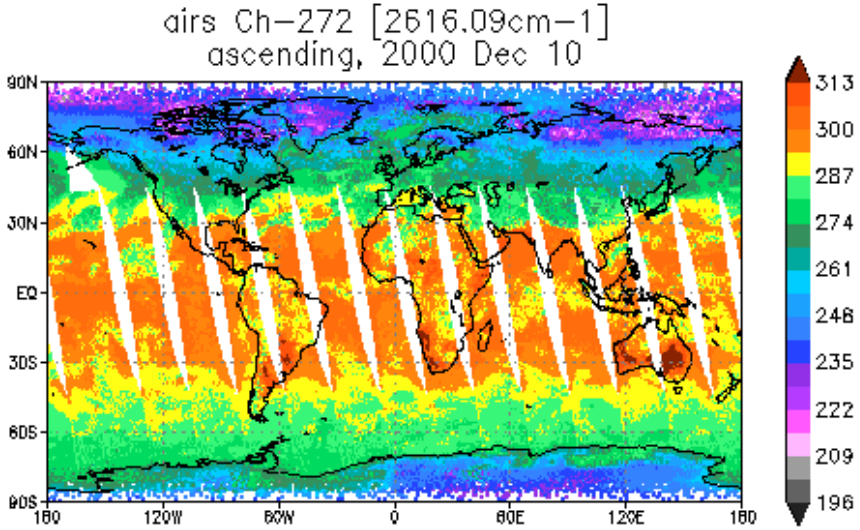


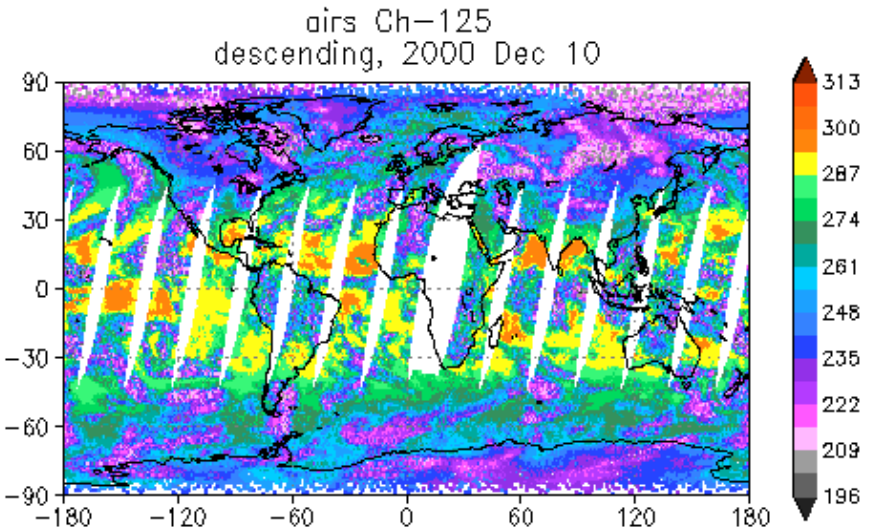
Example of model cloud top pressure and amount

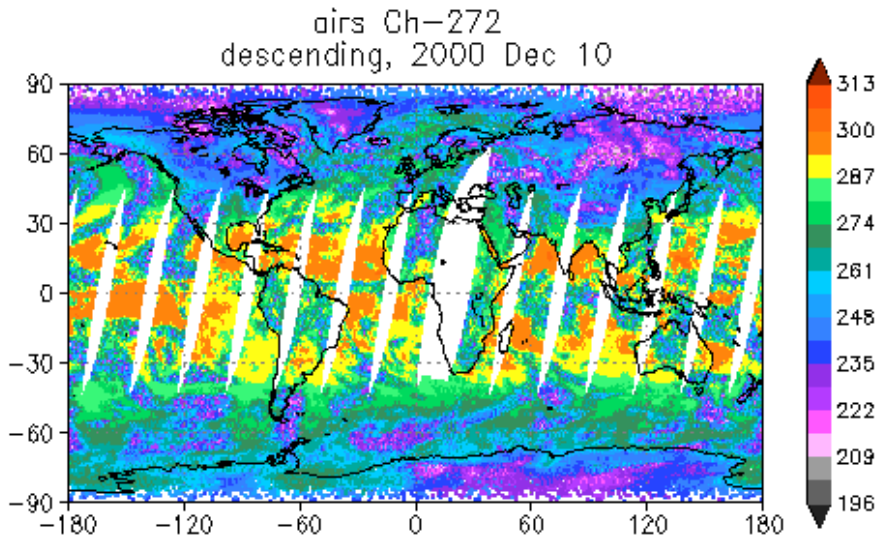


Example of simulated AIRS window channels: LW, SW

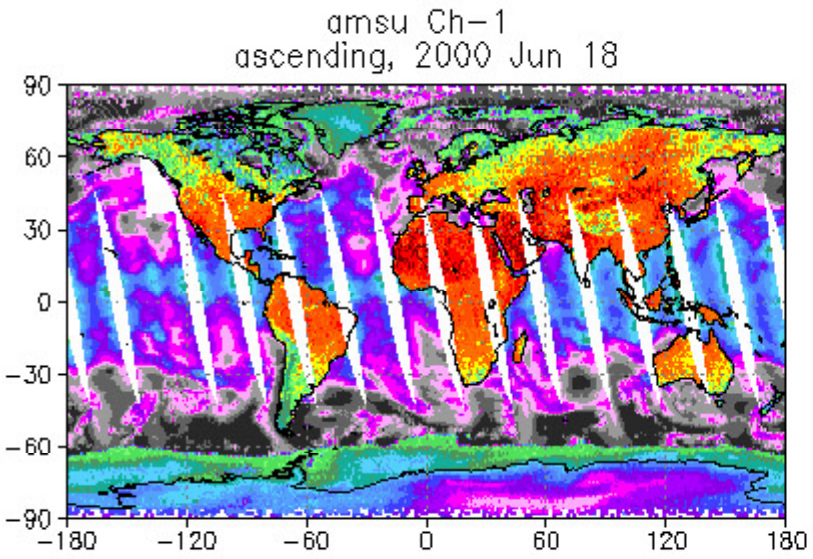


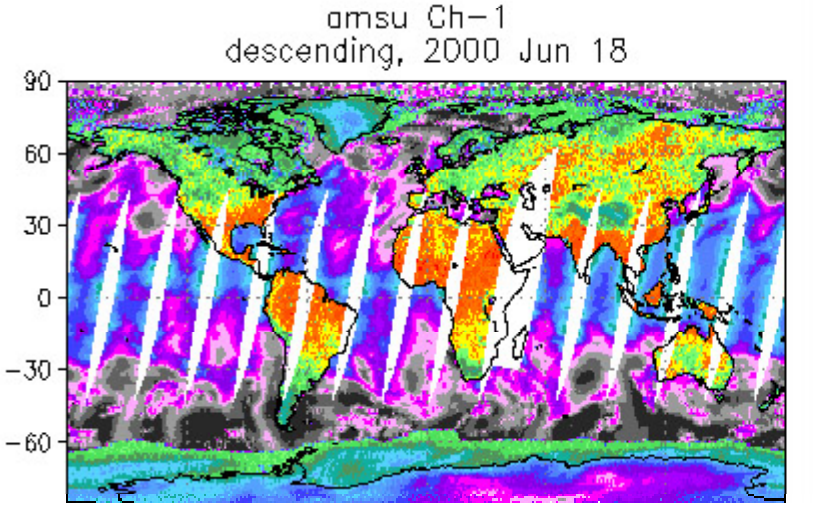




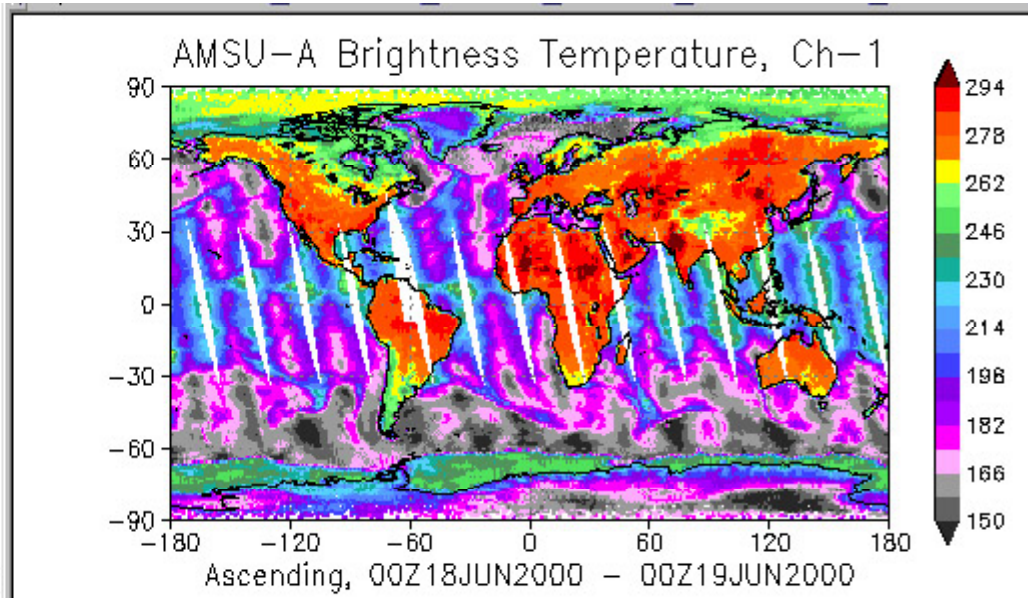


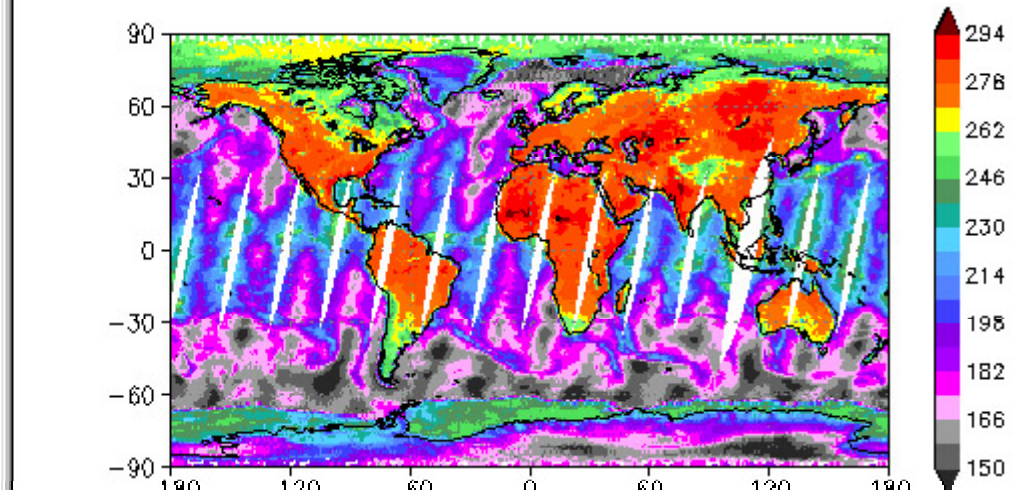
Simulated AMSU



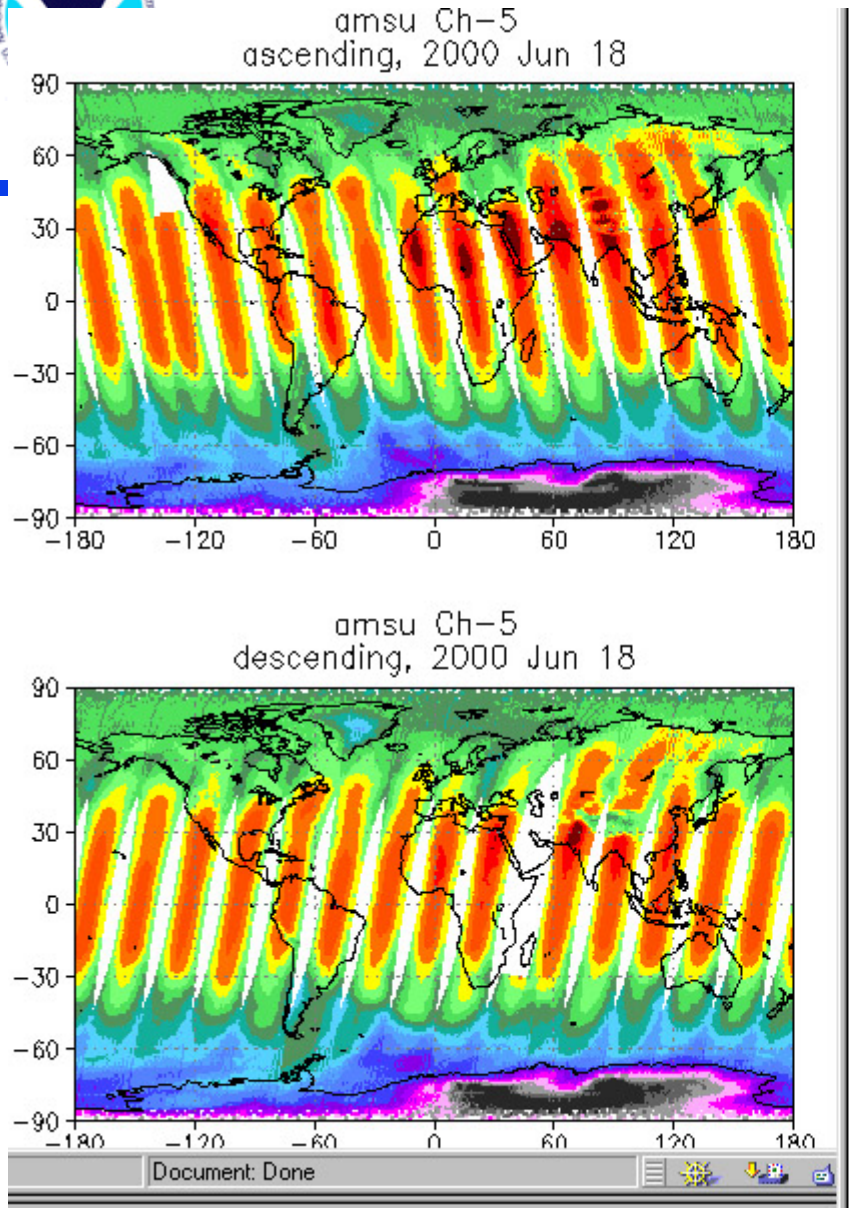


Real AMSU

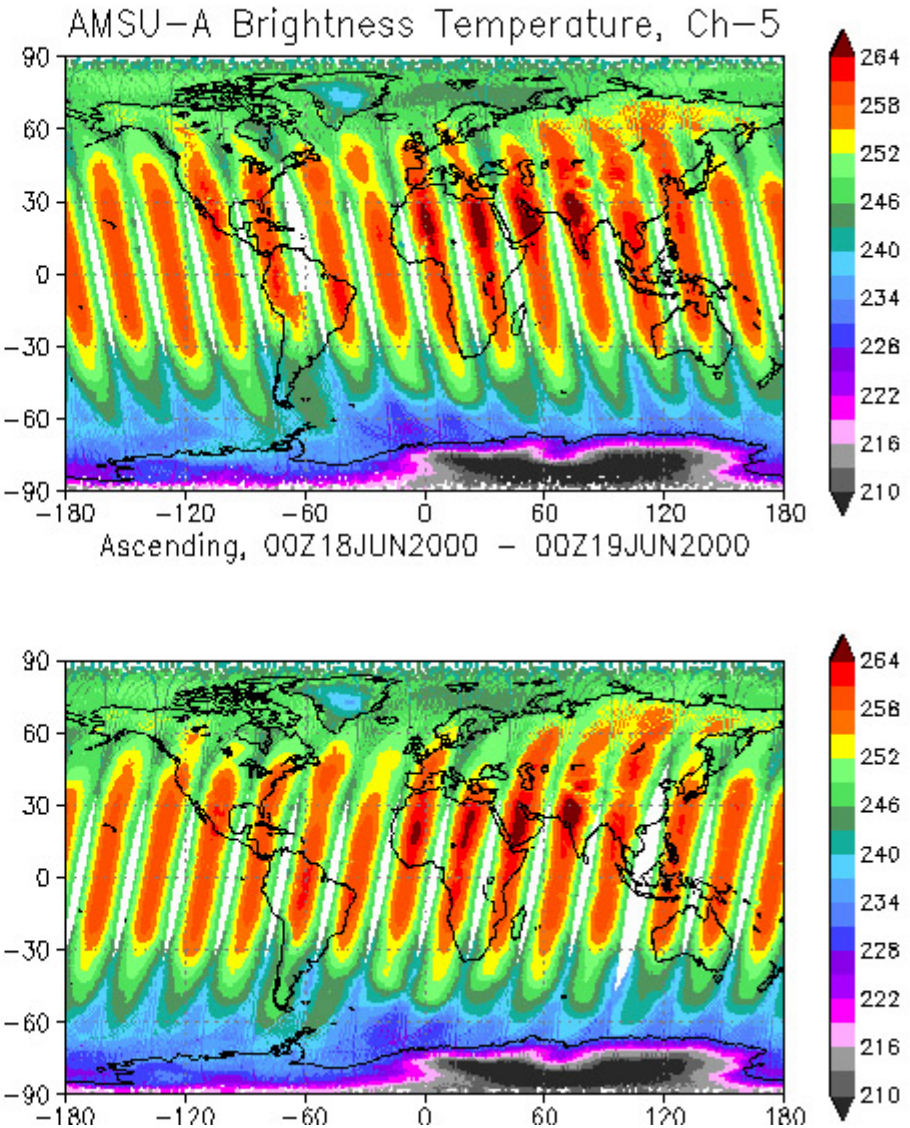




Simulated AMSU



Real AMSU



CLOUD DETECTION ALGORITHMS

- During the day VIS/NIR provides very accurate cloud mask – thresholds tests
- AIRS IR cloud detection algorithms rely on AMSU.
- MODIS type cloud thresholds tests can be used as well.
- Different approaches – still under development.
- Append cloud detection information to NWP radiances products.

Clear Detection – Combination of 3 tests

- AMSU channels 4, 5 and 6 are used to predict AIRS channel at 2390.9 cm-1.

*Predicted AIRS at 2390.9 = 11.327-.185*amsu4+1.930*amsu5-*
*0.777*amsu6+1.048*csza-4.243*(1.-cang)*

where csza = cosine solar zenith angle

cang = cosine view angle (scan angle)

amsu4 = amsu channel 4 brightness temperature , etc

- FOV is labeled "mostly clear" if predicted AIRS – observed AIRS < 2

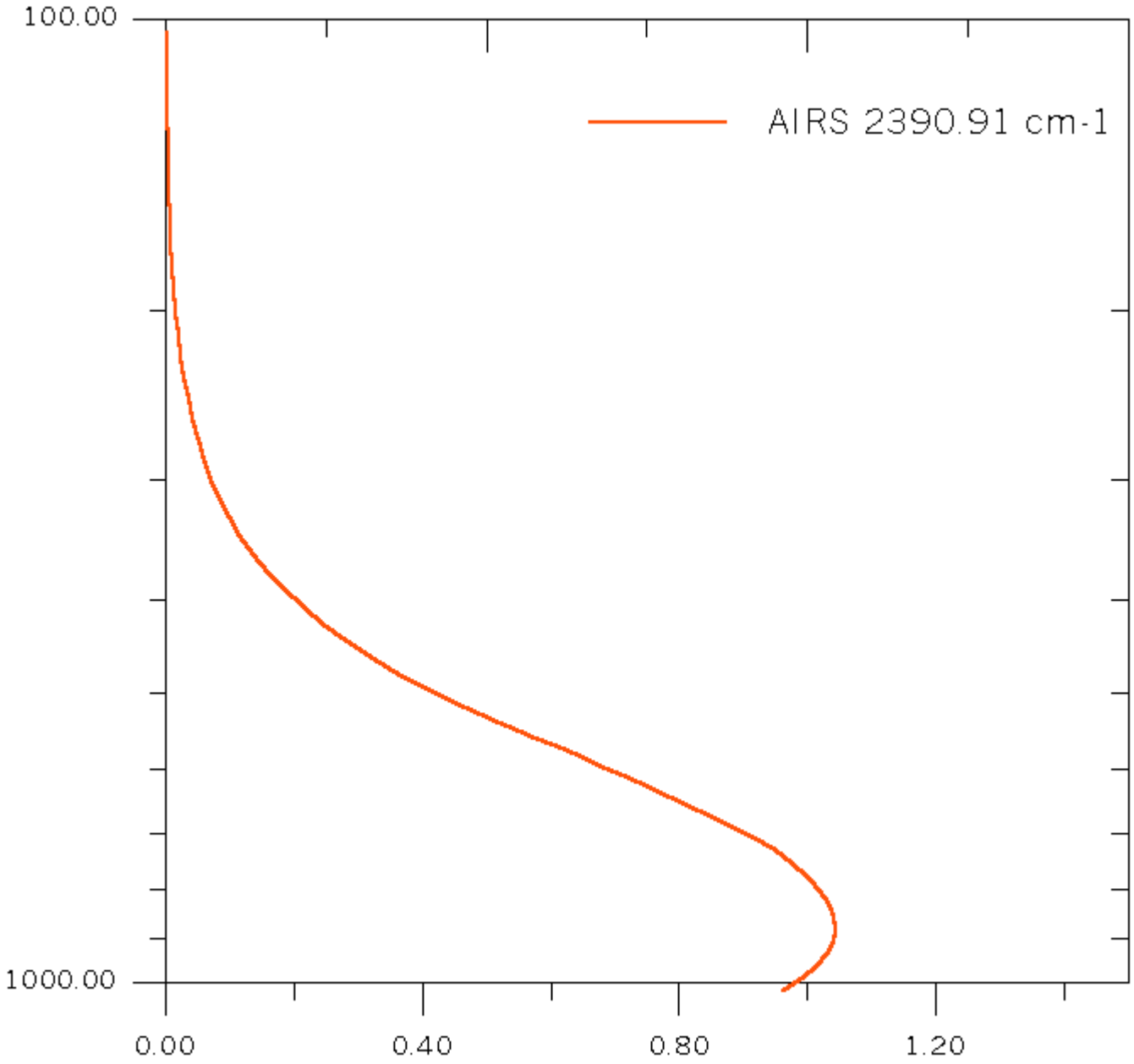
  AND IF

- SW LW IR window test is successful:

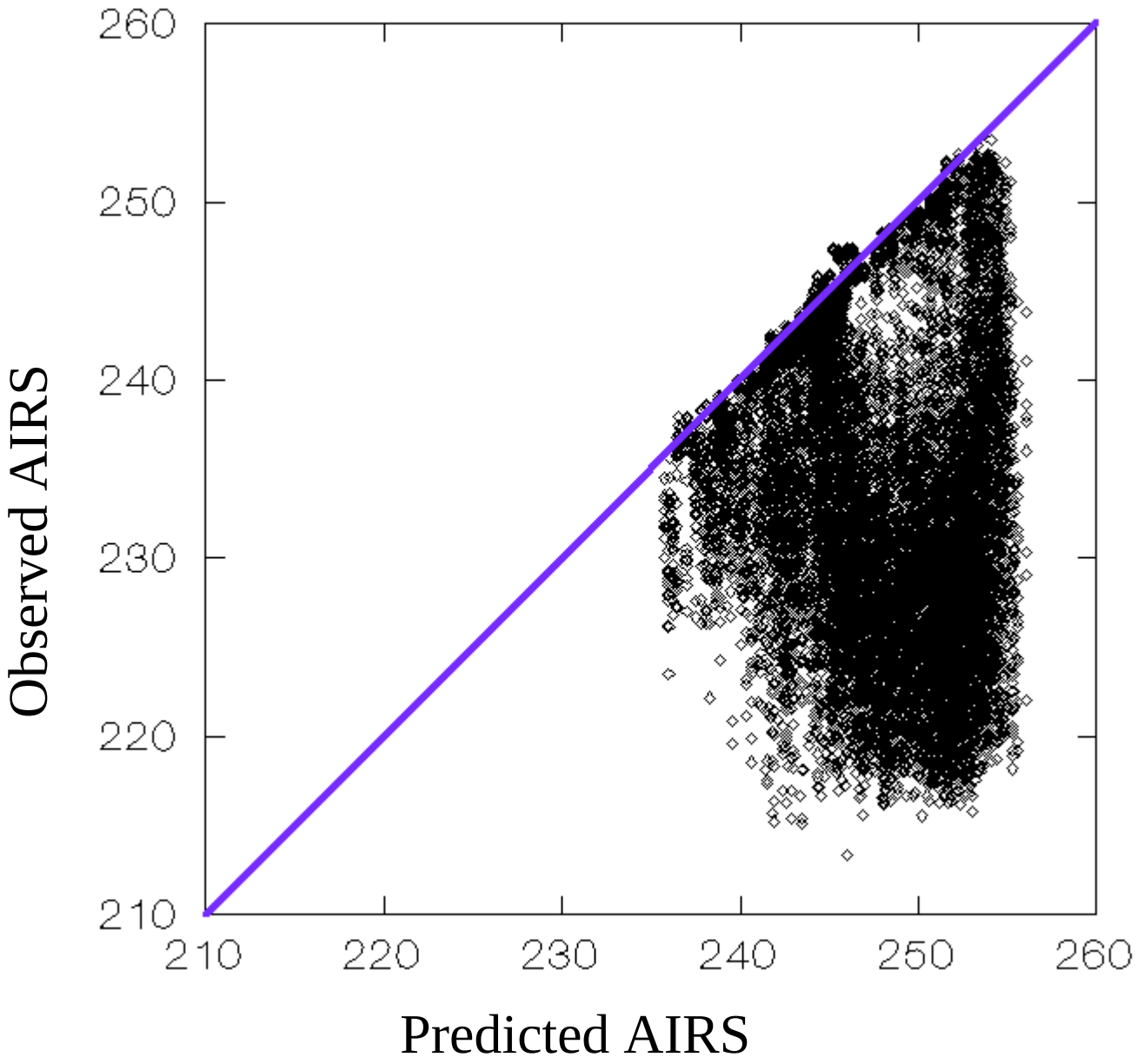
  [ch(2558.224)-CH(900.562)] < 10 K

- Variability of 2390.910 radiance within 3x3 < 0.0026

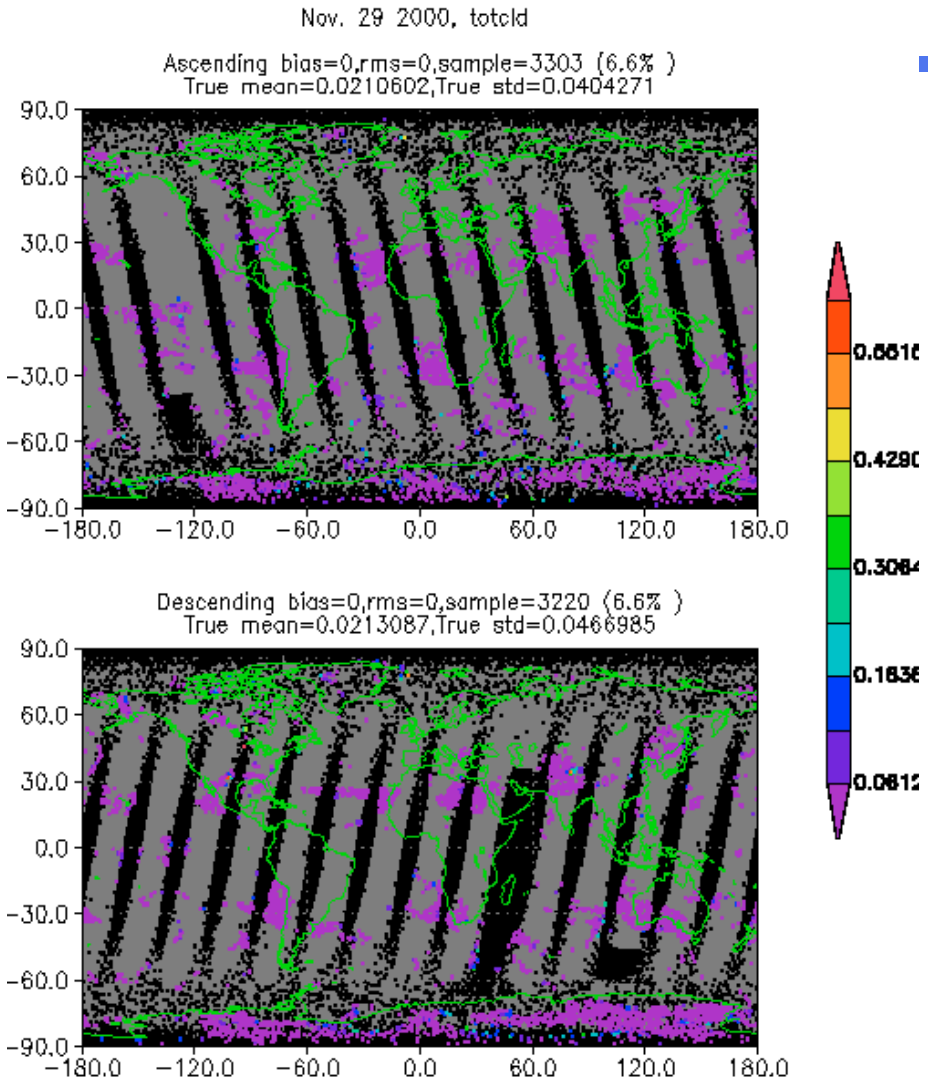
AIRS 2390.91 Weighting functions



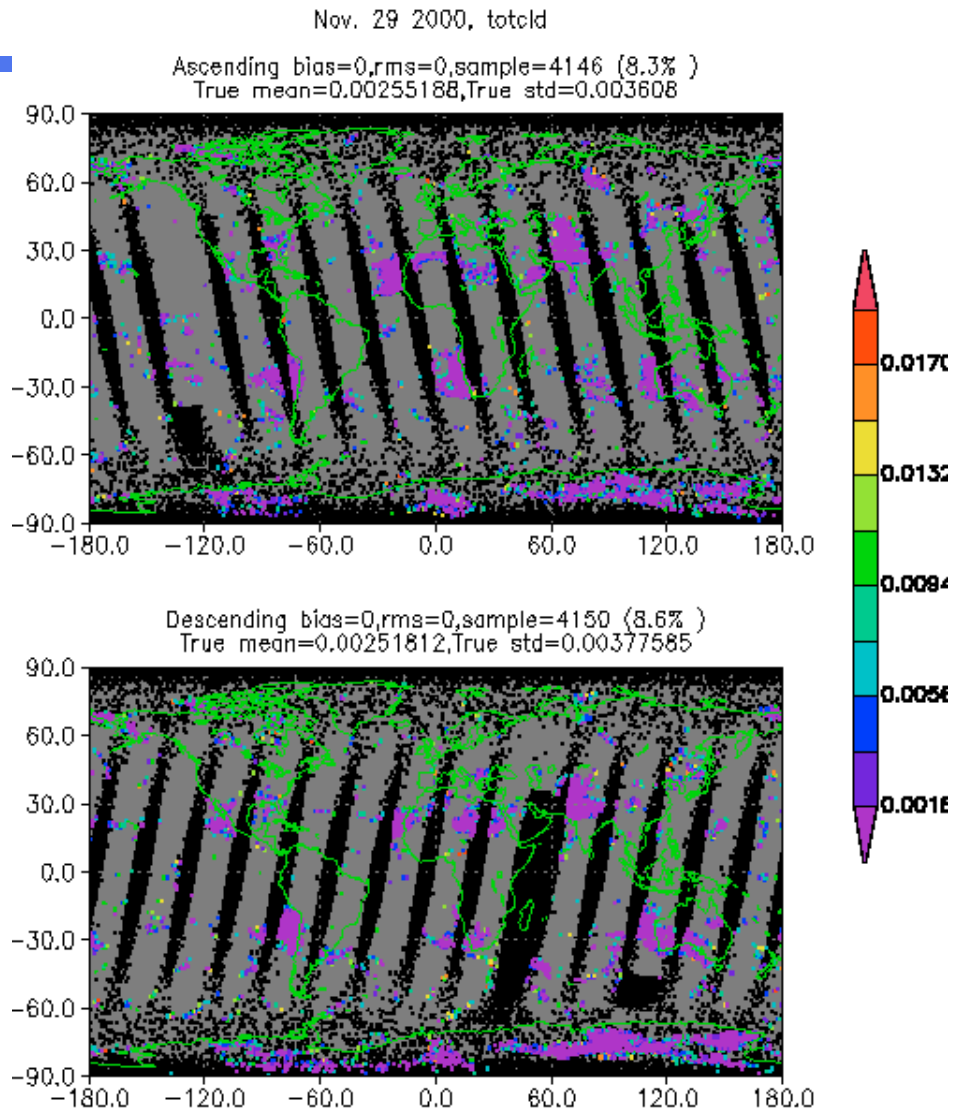
Predict AIRS from AMSU test



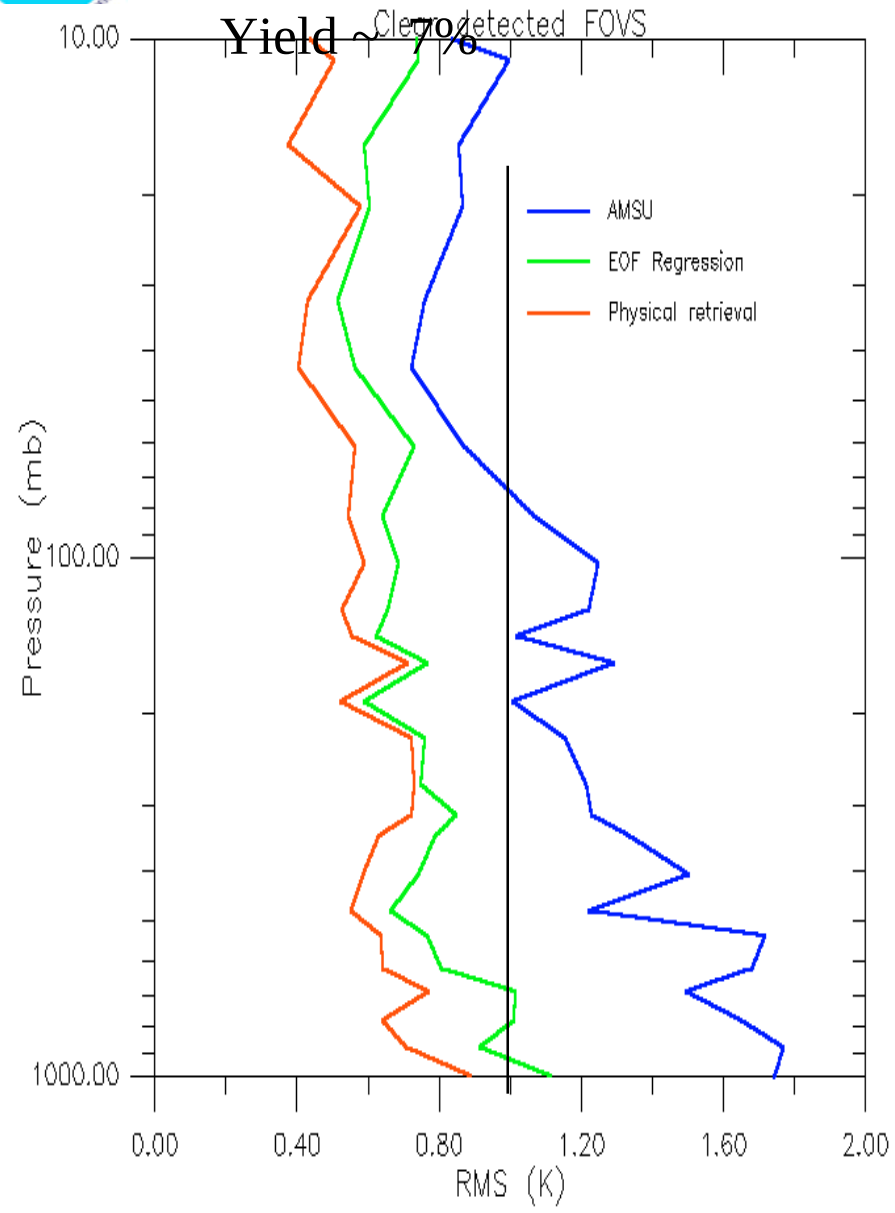
Total cloud (3 tests)



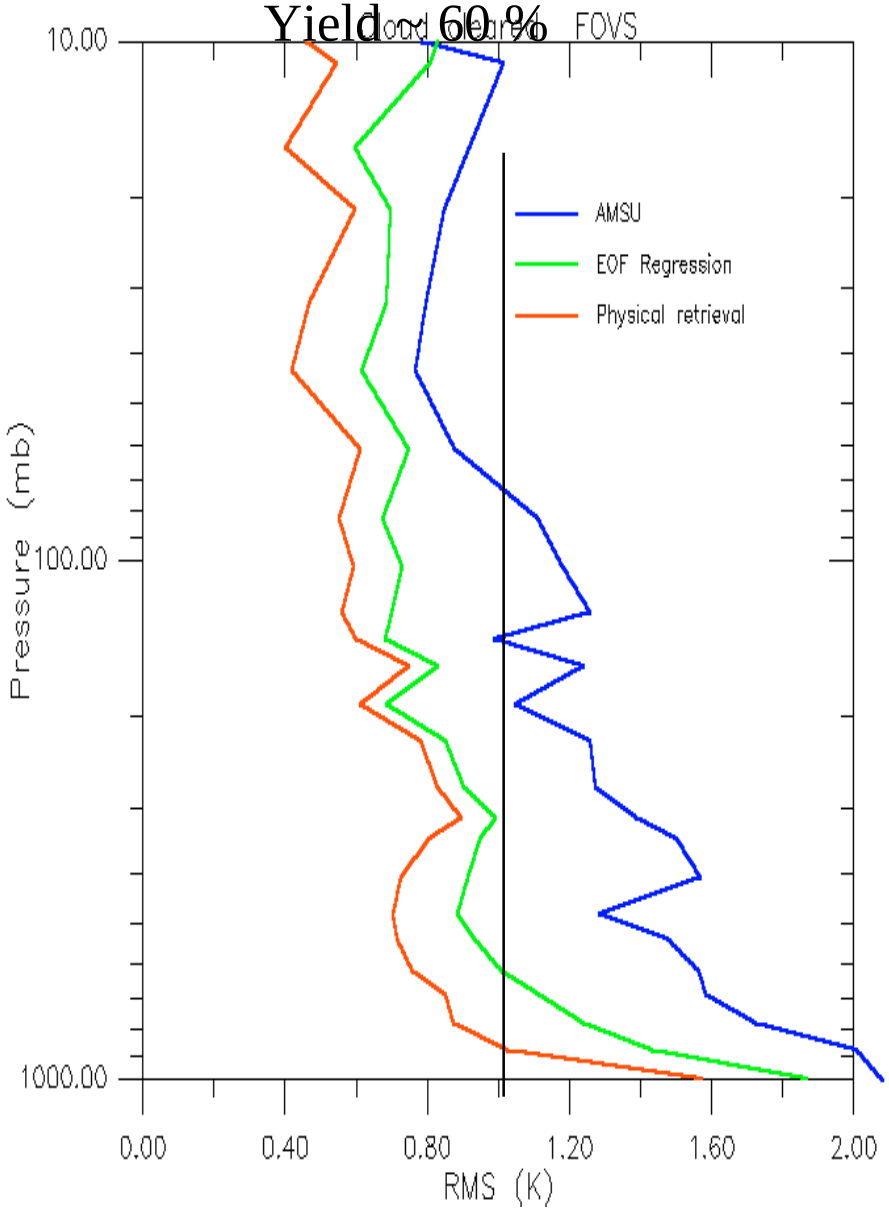
True clear (< 2%)



Yield ~ 7%



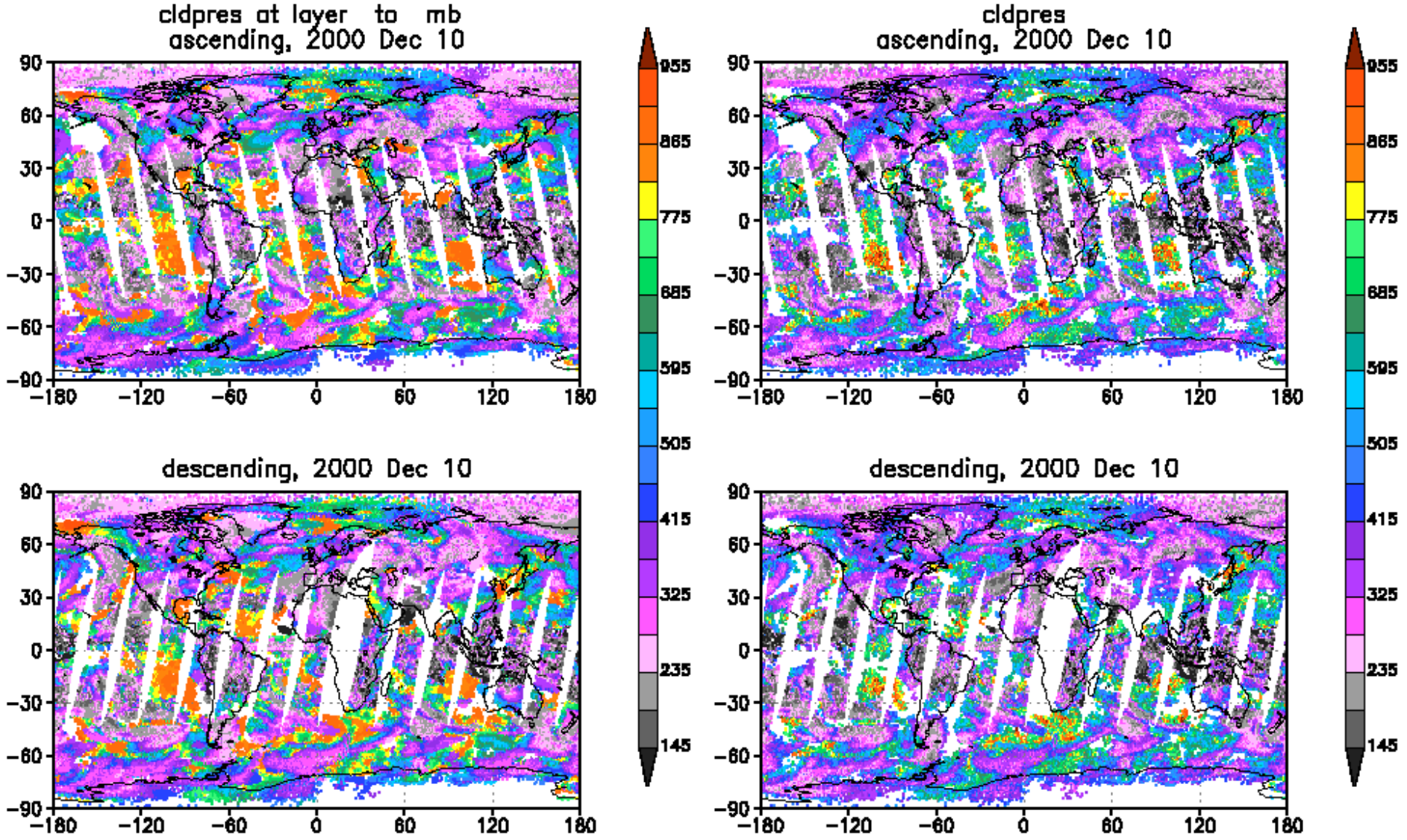
Yield ~ 60 %



Cloud top pressure and amount retrieval

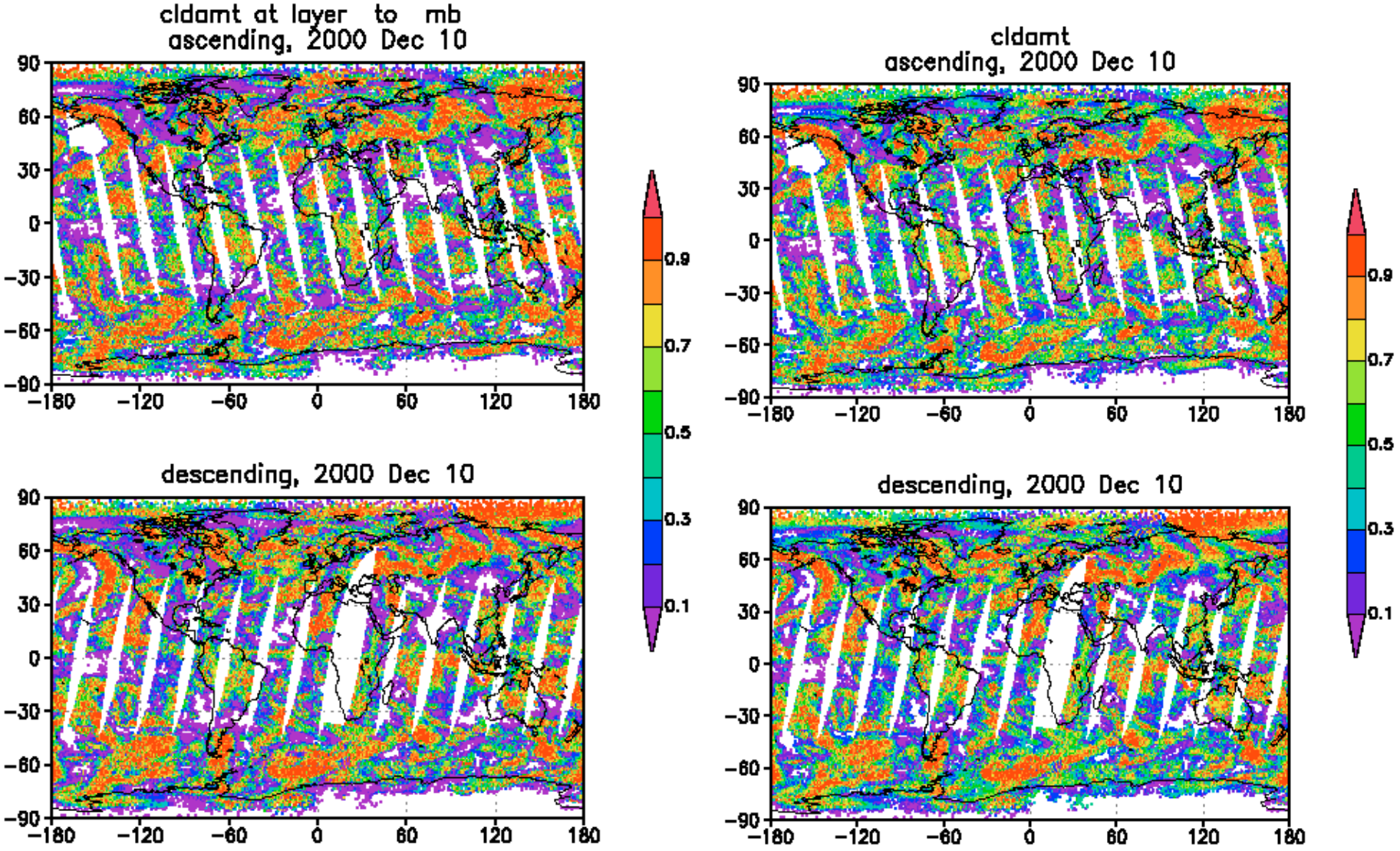
"TRUTH"

RETRIEVAL



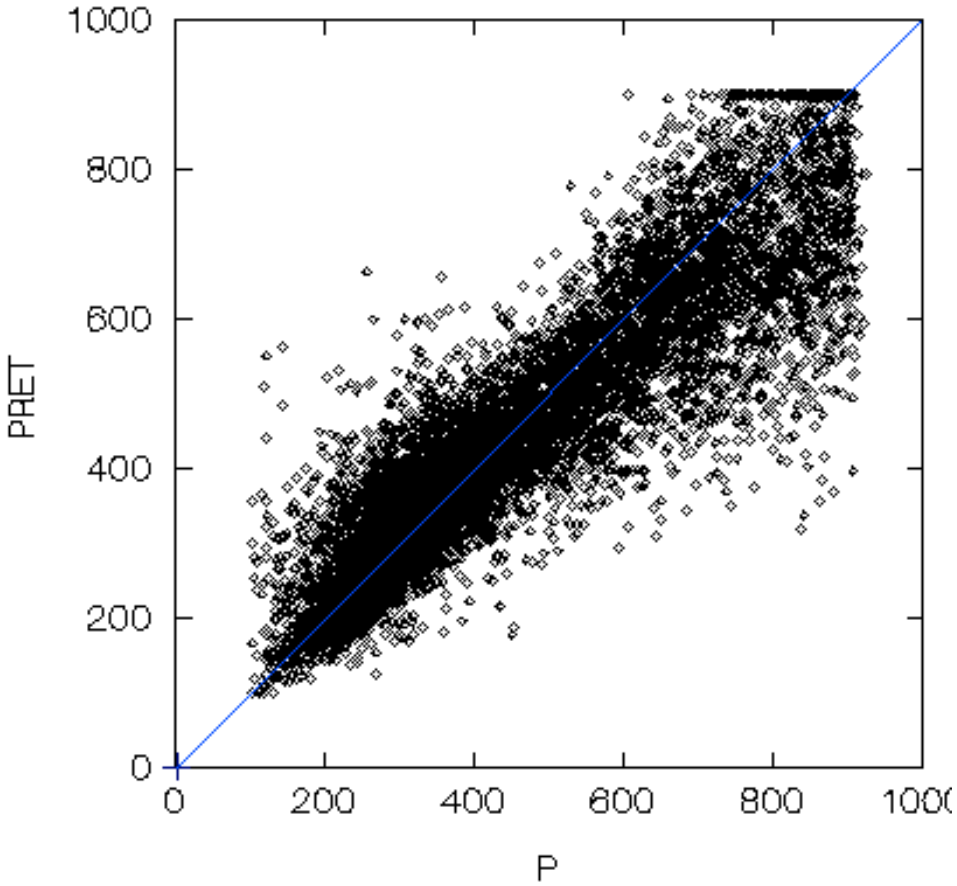
“TRUTH”

RETRIEVAL

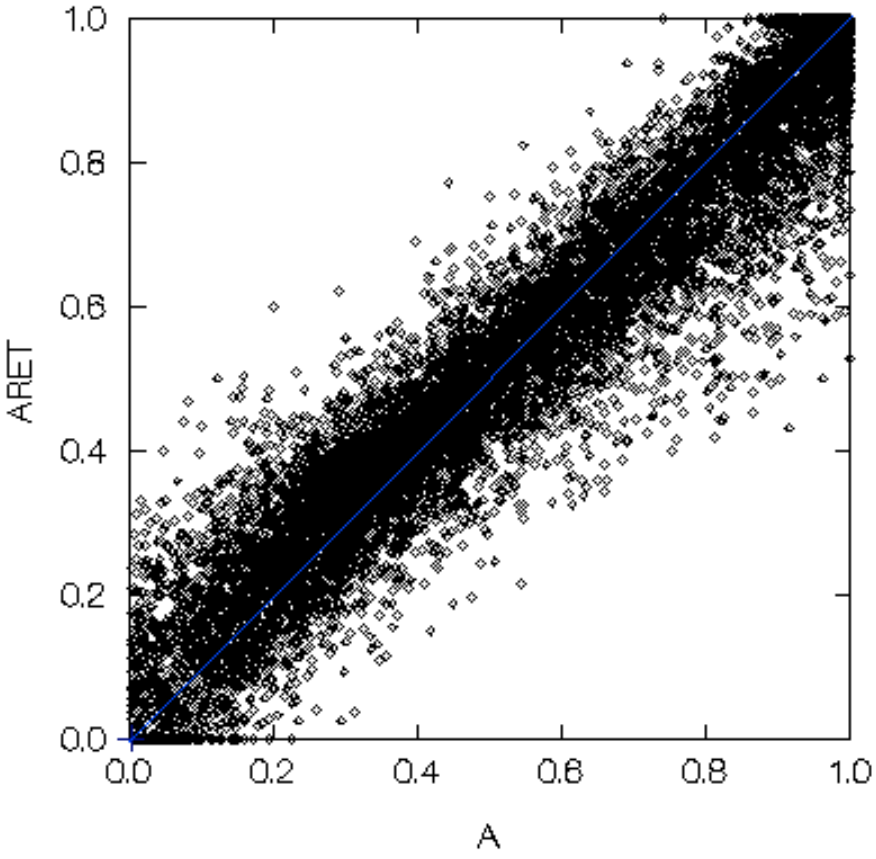


Cloud top pressure and amount -- overall errors

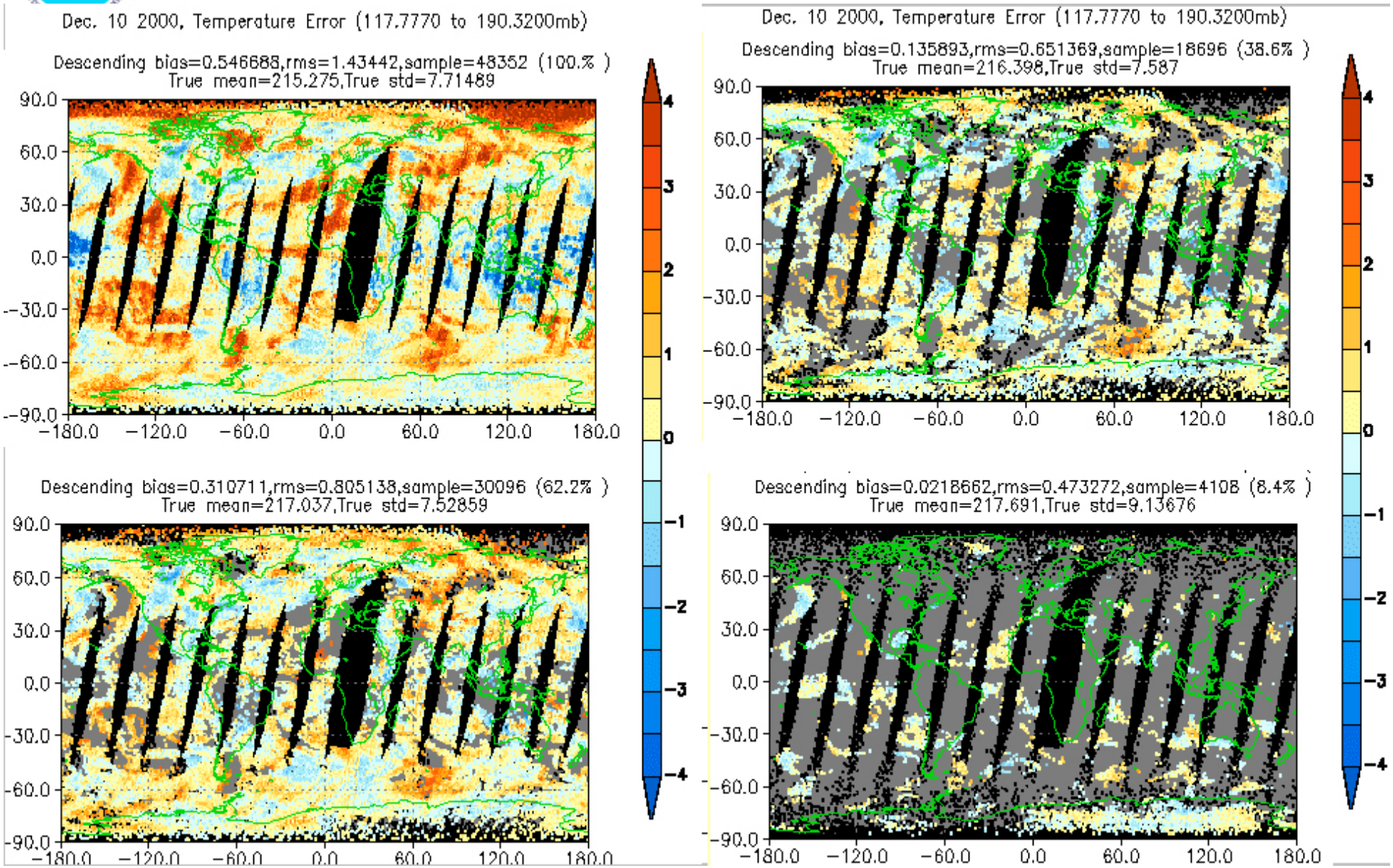
Error = 80 MB



Error = 0.085



Cloud top pressure and amount is very useful in omitting retrievals contaminated by clouds

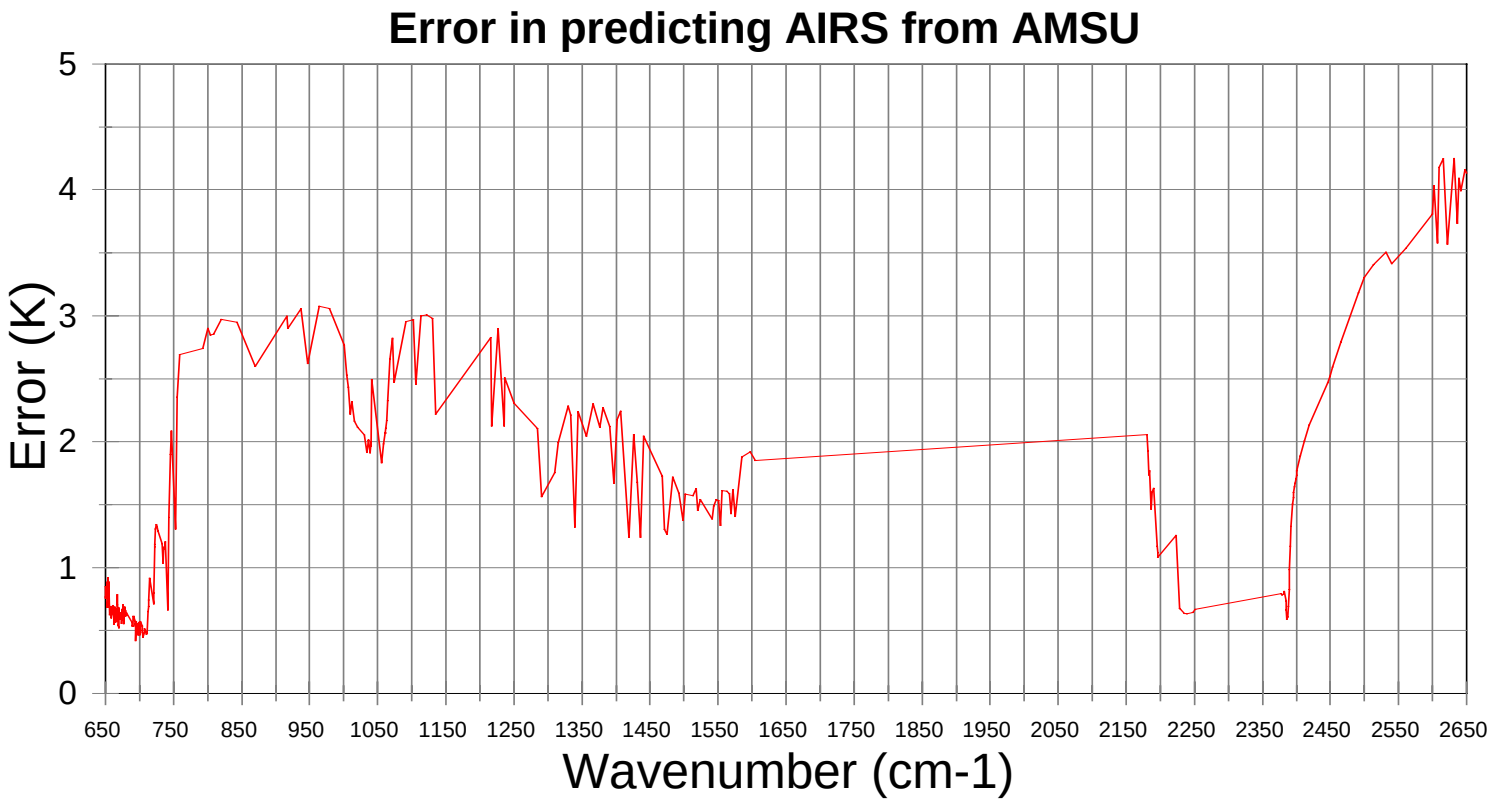


Problem

- Very few AIRS fovs are clear. ~ 7% are truly clear.
- Should NWP centers use cloud cleared radiances?
- QA of cloud cleared radiances will be provided.
- Try to make use of imager data for QA.

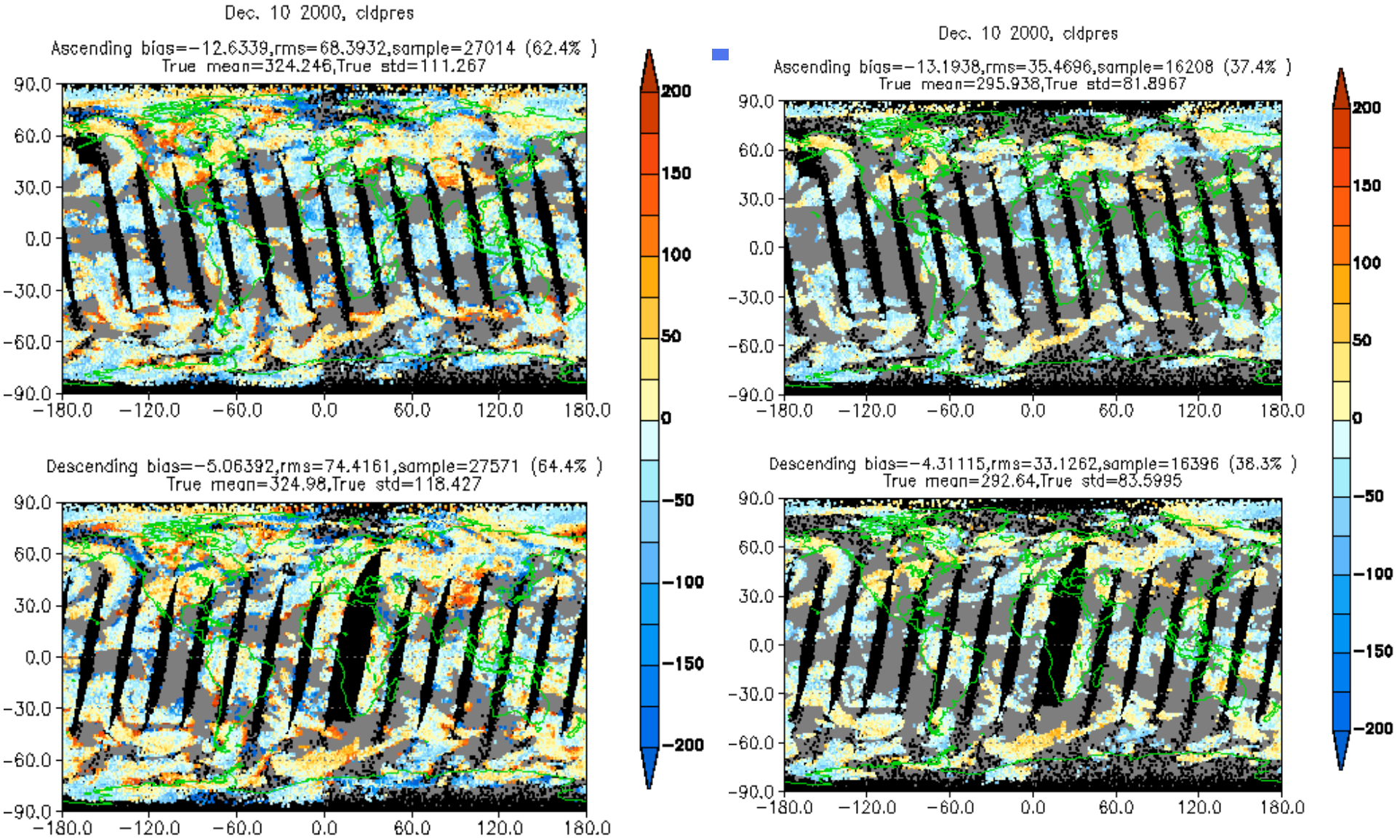
- Rclear = R1 + $\frac{\text{(clear-est. – R1)}}{\text{(R1-R2)}}$ (R1-R2)
- Need to check magnitude of “eta” to avoid cases of appreciable noise amplification.

- Problem is that clear estimate is from AMSU.
- Prediction of lower peaking AIRS channels from AMSU is poor.
- Clear estimate could come from somewhere else, such as from MODIS or NWP forecast.


Error in predicting AIRS from AMSU
Error (K)
0
1
2
3
4
5
650
750
850
950
1050
1150
1250
1350
1450
1550
1650
1750
1850
1950
2050
2150
2250
2350
2450
2550
2650
Wavenumber (cm-1)

Clouds above 500 mb

Cloud fraction >0.5

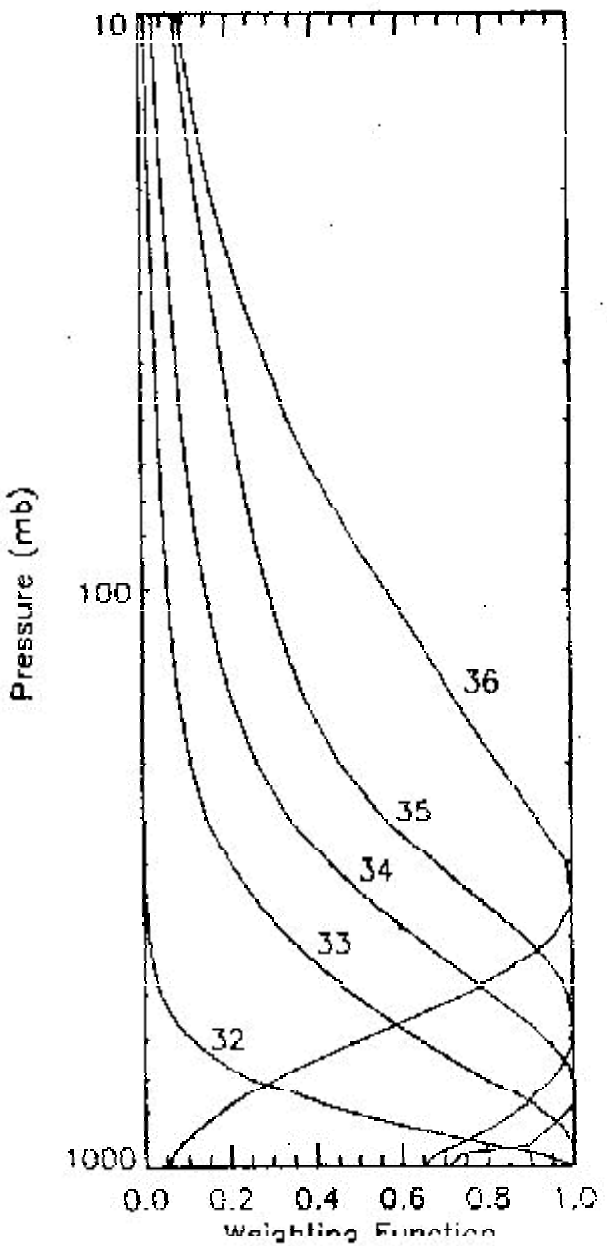


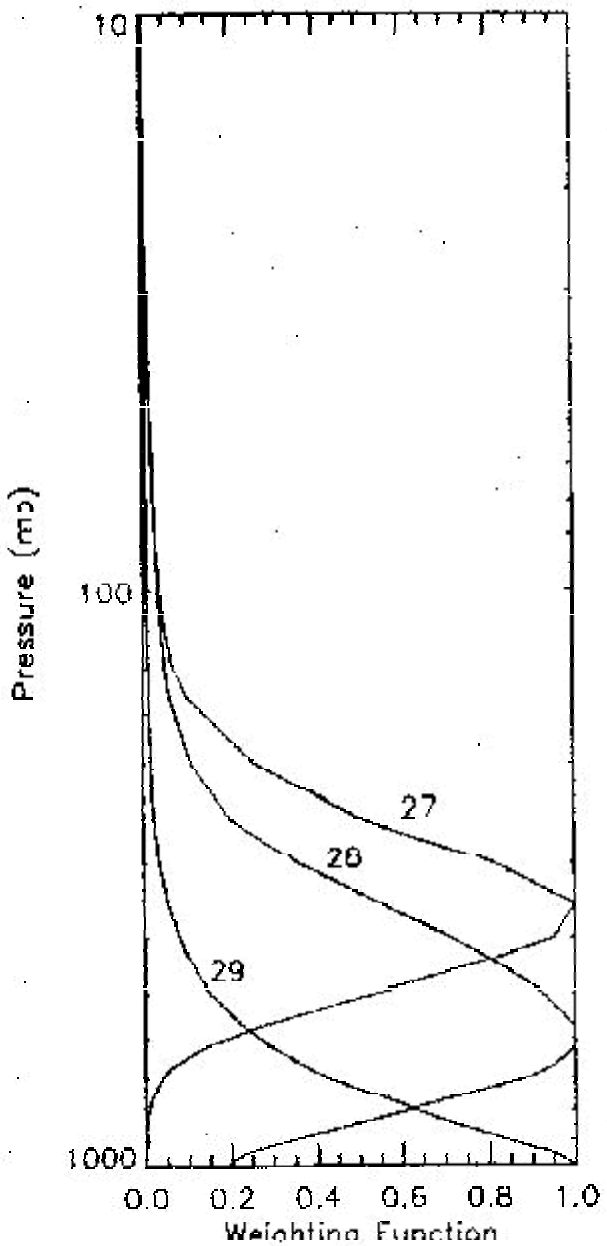
Cloud Cleared Radiance Product for NWP

- Cloud cleared radiances will have ancillary information such as:
- Cloud fractions and cloud top pressures of 3x3.
- Noise amplification (eta)
- Contrast.

Merging MODIS and AIRS

- High spatial resolution will improve determination of clear AIRS fovs.
- High spatial resolution will greatly improve clear estimate needed for cloud clearing.
- $$Rclear = R1 + \frac{(clear\text{-}est. - R1)}{(R1-R2)} (R1-R2)$$


10
100
1000
Pressure (mb)
36
35
34
33
32
0.0
0.2
0.4
0.6
0.8
1.0


10
100
1000
Pressure (mb)
27
28
29
0.0
0.2
0.4
0.6
0.8
1.0

Summary

- Work in progress
- Current cloud detection algorithm seems to be reasonable.
- Experiment with “MODIS” threshold tests.
- Cloud top pressure and amount retrieval is important for determining “good” retrievals.
- Combining MODIS and AIRS may improve determination of clear AIRS fovs and derivation of cloud cleared AIRS radiances.
- Assimilating cloud-cleared radiances should be considered.